



# **Exploration Systems Mission Directorate**

## **Analysis of Alternatives (AOA) Overview**

**Exploration Transportation Systems  
Strategic Roadmap Workshop**

**February 2005**



# ***Launch Systems Study Status***



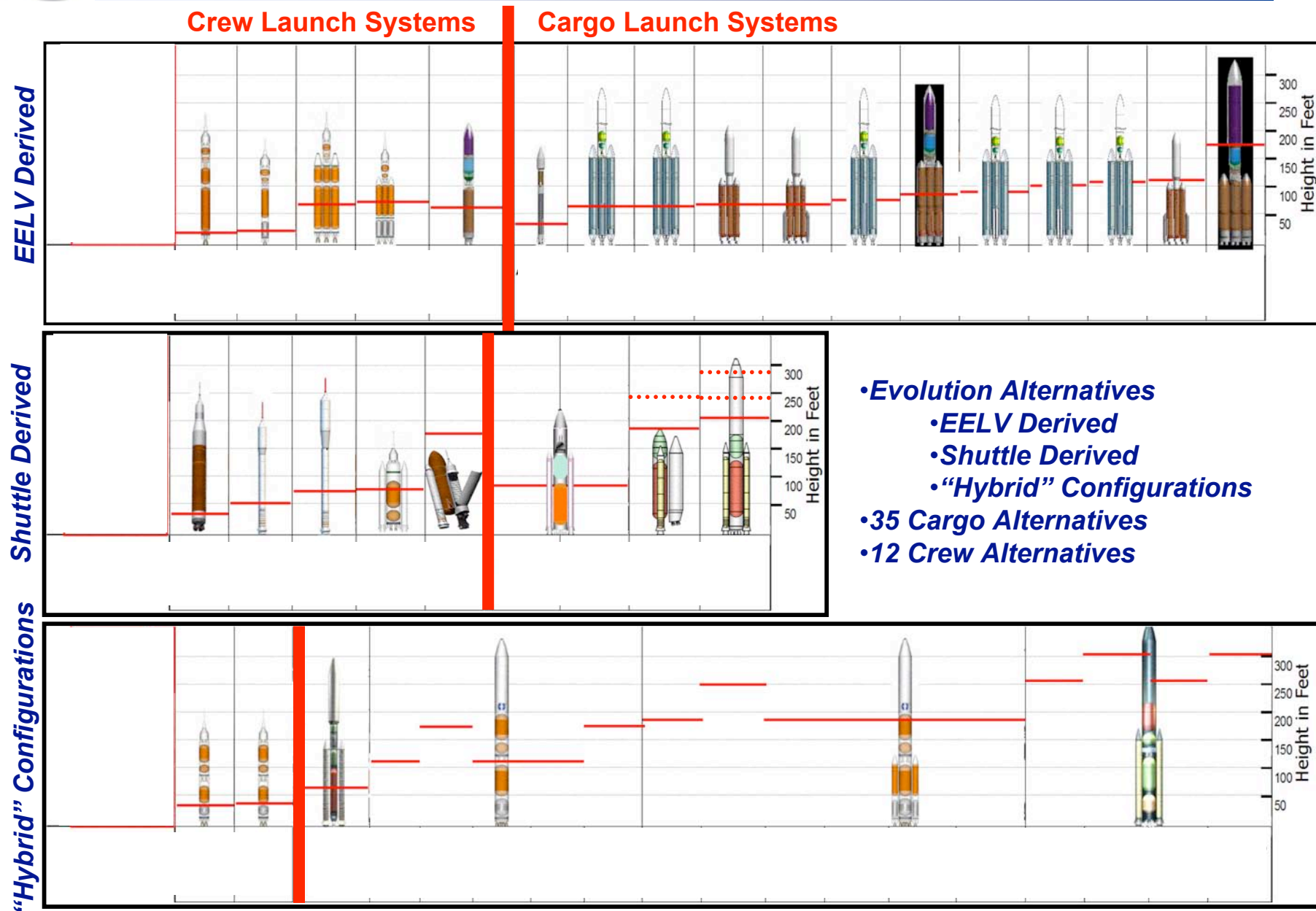
## **◆ Recently completed several in-house studies related to launch systems:**

- EELV Heavy Lift Cargo Assessment
- Integrated Launch Systems Study
  - Crew launch options (analyzed 12 systems)
  - Cargo launch options (analyzed 35 systems)
  - Upperstage / Earth Departure Stage commonality (3 classes)
  - Crew / Cargo Launch Vehicle Synergy
- KSC Launch Infrastructure Assessment
  - Analyzed the ground infrastructure requirements to support exploration missions

## **◆ Concept Exploration & Refinement (CE&R) BAA contractors will include launch needs as a part of their assessments**



# In-House Launch System Study Alternatives Completed





## *What we have learned so far*

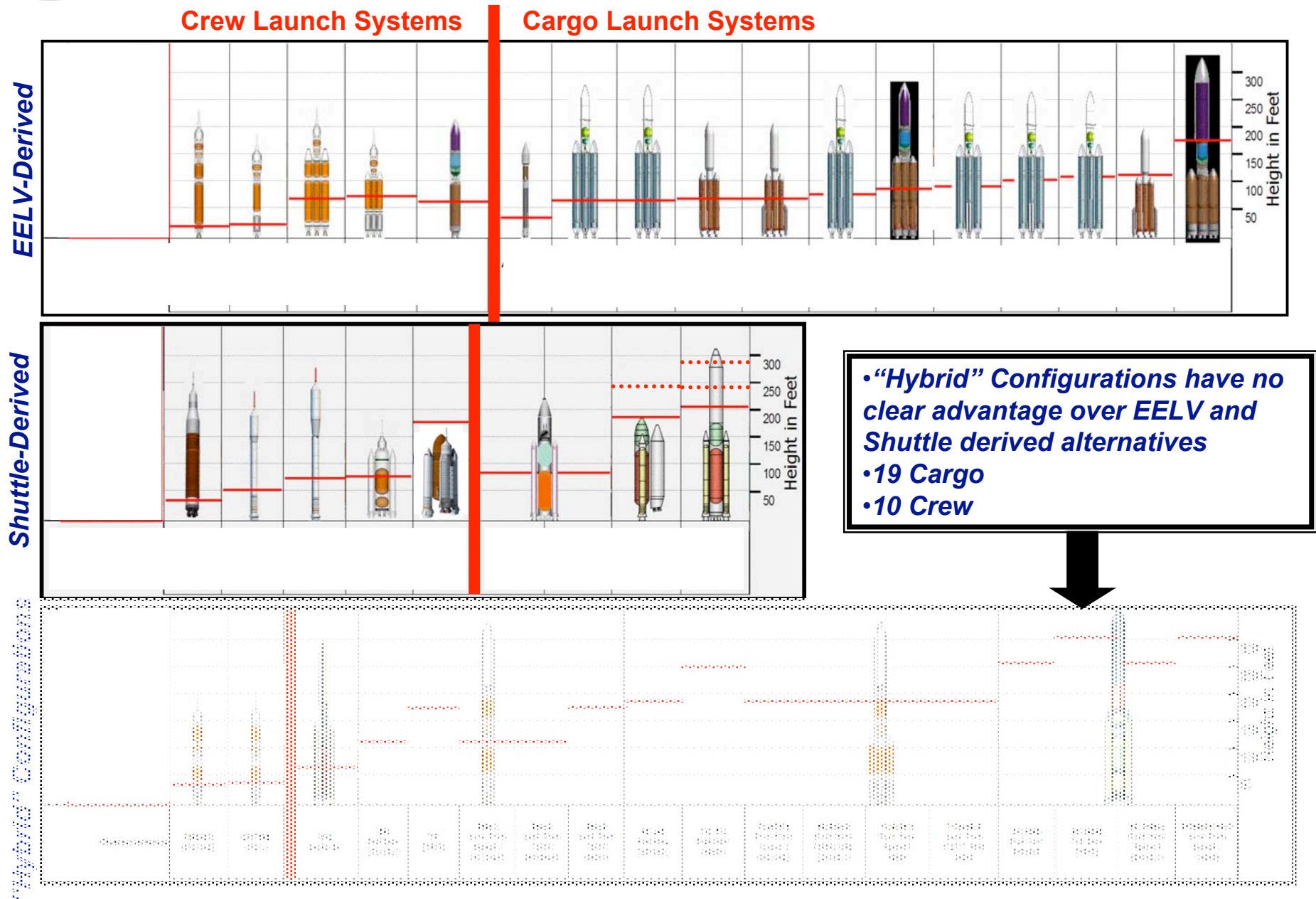


### ◆ **Launch Vehicle Study - Integrated assessment**

- Several paths exist to evolve from a crew to a heavy lift cargo capability
- “Hybrid” configuration options do not offer advantages over proposed EELV and Shuttle derivatives
- All human-rated launch system concepts assessed show the potential to meet the crew safety of 1/1,000
- DDT&E costs for human-rating or heavy lift capabilities will require significant government investment (costs will be validated via independent assessment)
- Cost effectiveness and reliability of launch system can be optimized by higher flight rates (multiple customers – e.g. NASA, AF, NRO, etc.)
- Clear capability bands identified to support the Analysis of Alternatives
  - 8 - 15 mT
  - 20 - 30 mT
  - 40 - 50 mT
  - 70+ mT



# Reduced Set of Launch System Alternatives

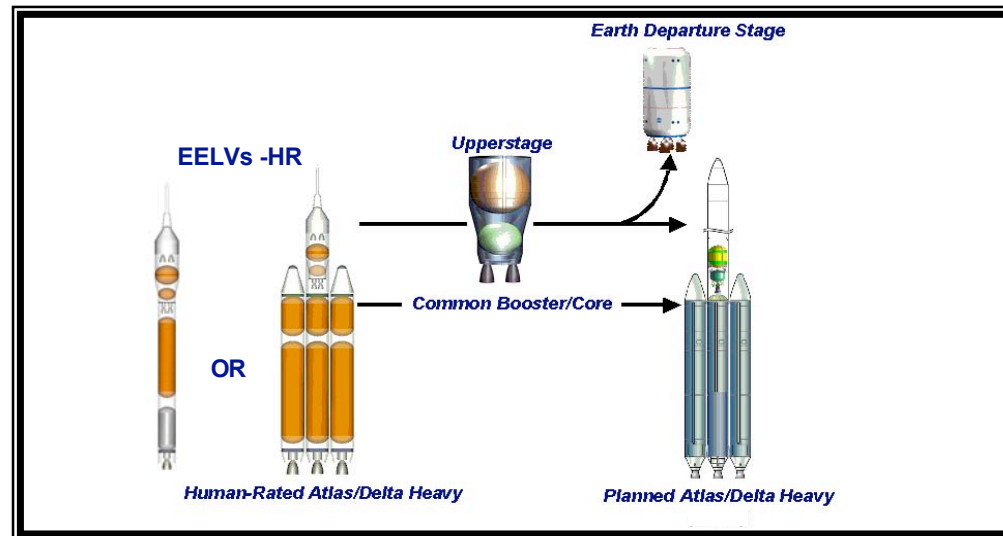




# Evolutionary Paths

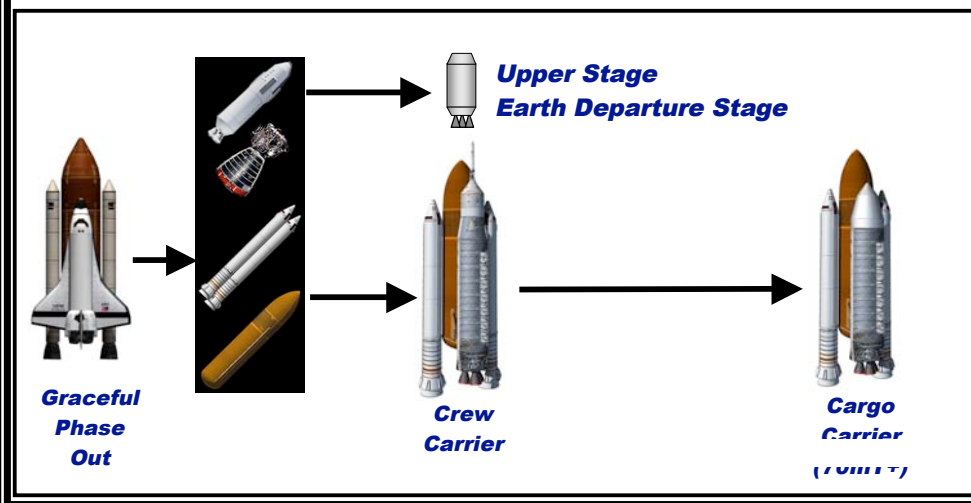


## Commercial/DoD EELV Paths

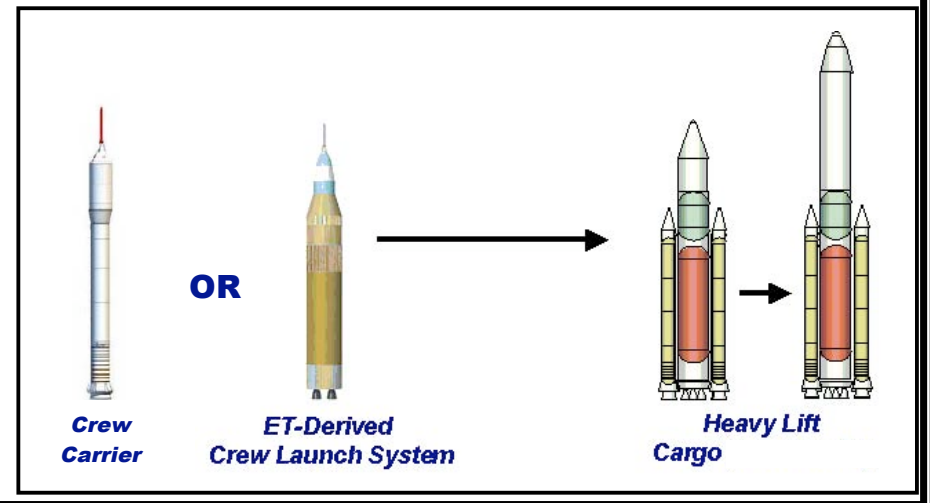


## Shuttle-Derived Paths

### Shuttle-Derived Sidemount Carrier



### Shuttle-Derived In-Line Carrier





# Background



## Purpose:

### ◆ Assess options to optimize overall lunar architecture

- Looking for the sensitivities within the architecture based on Launch Vehicle lift capability
- Alternatives include launch vehicle options and architectures variations
- Evaluate each option based on Figures of Merit (FOMs)

## Approach:

### ◆ Two-phase process

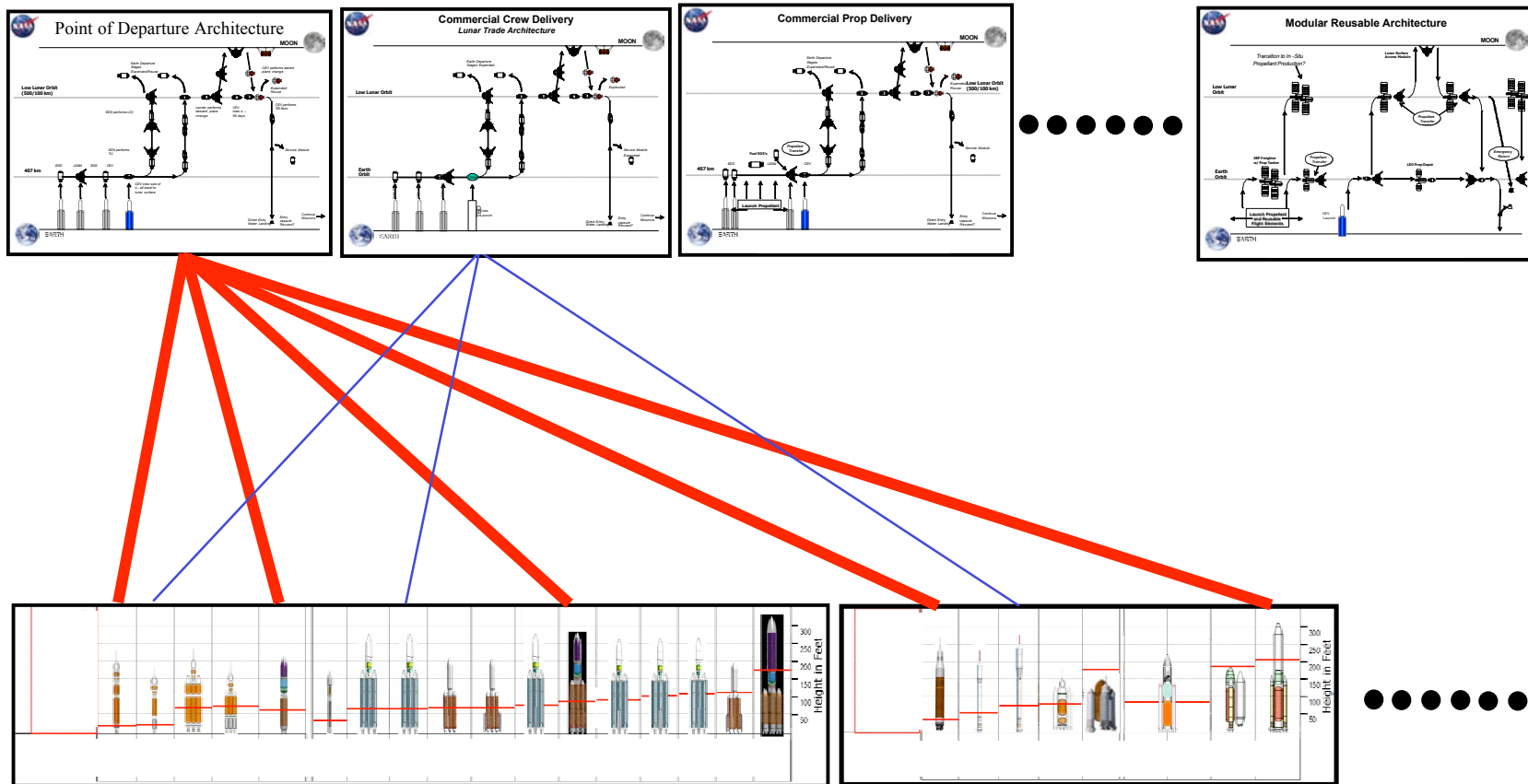
- Phase 1:
  - In-house Study efforts – mission architectures and launch vehicle concepts
- Phase 2:
  - Refined In-house data
  - Add CE&R Contractor concepts and Aerospace Corporation Independent Assessment data
  - Assessment of alternative architectures (eg. Commercial and modular)



# Approach



## Mission Architecture Options



## Launch Vehicle Options

**Multiple mission architectures assessed against multiple LV options**



# *Figures of Merit*



## ◆ **Crew Safety and Mission Success**

- Crew Safety - Launch phase
- Crew Safety – Abort Phase
- Mission success – Launch Campaign
- Mission success - Critical in-space events

## ◆ **Affordability**

- Non-Recurring Cost
- Recurring Cost
- Cost Phasing

## ◆ **Programmatic Risks**

- Technology Development risk
- Launch Processing/throughput risk
- Development Schedule risk

## ◆ **Extensibility**

- Evolvable to Mars Mission
- National Security Commonality
- Commercial Opportunities



## *What we have learned so far – Phase 1 AOA*



### ◆ **Crew Safety and Mission Success**

- All human-rated launch system concepts assessed show the potential to meet the crew safety requirement of 1/1,000
- Large number of in-space events may significantly increase mission risk even with fairly reliable launch systems

### ◆ **Affordability**

- DDT&E costs for human-rating could require significant government investment

### ◆ **Programmatic Risks**

- All options appear to be able to support the Vision major milestones
- Traffic model (quantity and spacing) drives significant manufacturing and launch site infrastructure
- Some launch vehicle options require technology development

### ◆ **Extensibility**

- Heavy Lift capabilities are favored for Mars Missions
- Potential Commercial Opportunities exist



## ***Work Ahead***



- ◆ **Continue looking for the sensitivities within various architectures based on Launch Vehicle lift capability**

**No down-select of Launch Vehicle has been made**

- ◆ **Continue with AOA Phase 2**
  - Assess Mixed Fleet LV options and other transportation options
  - Refine cost assessments for ALL scenarios
- ◆ **Provide Integrated Assessment**
  - Identify Agency-wide synergy
  - Assure compliance with Space Transportation Policy